PACKET COMMUNICATION DEVICE

FIELD OF THE INVENTION

The present invention relates to a packet

5   communication device capable of easily adding a function to

be requested and on adding the function, capable of

minimizing a time period for suspending the service.

BACKGROUND OF THE INVENTION

10   In recent years, data traffic mainly based on use of

Internet has been abruptly increasing. There is also a move

afoot to do, on the Internet, highly reliable service of high

quality such as transaction processing which has

conventionally been performed using a leased line. In order

15   to cope with this, it is required to meet the tendency of

not only a transmission path, but also the packet data

communication device with larger capacity, higher speed and

higher reliability. Further, in order to cope with a new

routing protocol or a new service quickly in the future, or

20   in order to make it possible to simply add a necessary

function, the flexibility of adding a function is requested

for the packet data communication device.

For example, a router device performs layer 3

processing as a packet data communication device.

25   Particularly, many high-performance router devices enable

high performance routing and forwarding with hardware. The structure of a hardware router has been disclosed in Non-patent Literature 1, for example.

Fig. 12 shows an outline of a hardware router

5   disclosed in the Non-Patent Li1terature 1. A plurality of routing processors 801 each having a network interface 811 are connected to each other through a crossbar switch 800. Each routing processor 801 is composed of: a forwarding controller 812; a routine processor 813; a routing table

10   814; and a packet buffer 815. A header of an incoming packet from the network interface 811 is extracted by the forwarding controller 812, and the route is retrieved by hardware in the routing processor 813. In the routing table 814, output destination information corresponding to a

15   destination IP address, security-oriented filtering information and information of QoS (Quality of Service) are stored beforehand. The IP packet, search processing of which has been completed, is inputted into the packet buffer 815, and after arbitration for output among other routing

20   processors 801 is performed, is transferred to a desired output port through the crossbar switch 800. The routing manager 802 deals with a routing protocol, which transmits and receives routing information to or from other routers connected thereto to determine a forwarding path of each IP

25   packet. The forwarding path thus determined is reflected

to the routing table 814 within the routing processor 801. As described above, this is constructed such that the routine processors and the packet buffers are separated.

Another example of the structure of hardware router

5   is disclosed in a Patent Literature 1.

Fig. 13 shows an outline of a hardware router disclosed in the Patent Literature 1. An incoming IP packet through an input port 901 is stored in a buffer memory 903 through an input switch 902. In the input switch 902, KEY

10 information 904, such as a destination IP address in the IP packet, is read out and transferred to a controller 905. In the controller 905, after destination search processing for each packet is performed, this result (RESULT 906) is transmitted to an output switch 907. In the output switch

15 907, the IP packet stored in a buffer memory 903 is read out on the output port 908 according to the RESULT 906. As described above, this is constructed such that the routing processor and the packet buffer are centralized.

Furthermore, in a Patent Literature 2, there has been

20 disclosed a hardware router in which a labeling packet and the IP packet are judged by an input line interface, and the IP header is transmitted to a forwarding engine for being processed according to the judgment result. However, no consideration has been given to scalability or

25 extensibility of the processing.

[Non-Patent Literature 1]

Itaru Mimura and two others, "Terabit Node for Next-generation IP Networks", [online], December 2000, HITACHI REVIEW, [retrieved on January 30, 2003], Internet,

5 <URL:

http://global.hitachi.com/Sp/TJ-e/2000/revdec00/pdf/r4_1 03.pdf>

[Patent Literature 1]

U.S. Patent No. 5905725

10 [Patent Literature 2]

JP-A No. 64542/2002

The switch shown in the Non-Patent Literature 1 is comparatively high in scalability in processing capacity because the routing function and the forwarding function are

15 separated. In the structure shown in the Non-Patent Literature 1, however, the forwarding controller and the routing controller are tightly coupled and are mounted on the same routing processor. When it is considered that these are implemented with hardware, in order to cope with new

20 routing protocol or a new service quickly, the whole hardware needs to be modified. In other words, the structure is not suitable for adding new function easily.

Also, the switch disclosed in the Patent Literature 1 has good efficiency of buffer memory usage, because the

25 routing function and the forwarding function are

centralized, and has a feature that the device can be downsized. However, it is difficult to scale up this structure, because processing of the routing function and the forwarding function is prone to become a bottleneck of

5 the system. Therefore the structure is inferior in terms of performance scalability. The routing function and the forwarding function are separated in this system and in order to, for example, cope with new protocol, it is required to remake the routing hardware. Therefore it does not have

10 flexibility in adding a function. Besides, this system does not have a structure in which any application layer services can be added as needed.

SUMMARY OF THE INVENTION

15 An object of the present invention is to provide a packet communication device having flexibly in terms of adding a function. Specifically, a packet communication device of minimum subset structure having only a simple packet forwarding function, is provided as a base model.

20 Also, in order to implement function of scalability and upgradability, it is another object of the present invention to provide a packet communication device capable of adding functions such as application layer processing and functional service to the base model as needed. More

25 specifically, it is still another object of the present

invention to provide a packet communication device such that an incoming packet may be able to selectively use one or a plurality of these functional services when a plurality of functional services is provided. Further, it is still

5   another object of the present invention to provide a packet communication device having such performance scalability as to easily enhance and upgrade the performance without suspending the service according to necessary performance of the same function.

10   To solve the above-described problems, the present invention provides: a plurality of line interfaces capable of at least one of reception and transmission of a packet; a plurality of ports, to which the plurality of line interfaces are connected, and to which at least one

15   functional processor, to perform functional processing on an incoming packet received by any of the plurality of line interfaces, can be installed as needed; a function item judgment unit for judging a function item to be required for the incoming packet; a forwarding information generator for

20   determining a forwarding port for the incoming packet in accordance with the function item obtained by judging by the function item judgment unit, and imparting, to the incoming packet, the forwarding information, that is information for designating the forwarding port; and a forwarding path

25   switching unit for switching the forwarding path when

forwarding among the plurality of ports on the basis of the forwarding information.

The present invention exhibits the following effects:

(1) When constituting a packet communication device, it is possible to provide a packet communication device having such function scalability as to be able to add functions such as application layer processing and functional service to the base model as a functional module with a packet communication device having only a simple forwarding function of, for example, layer 2 or layer 3 as a base model.

(2) It is possible to provide a packet communication device having such function scalability as to be able to add functions such as application layer processing and functional service to the base model as a functional module with a packet communication device having only a simple forwarding function of, for example, layer 2 or layer 3 as a base model, in which when a plurality of functional services is provided, an incoming packet is capable of selectively using one or a plurality of these functional services.

(3) It is possible to provide a packet communication device having such function scalability as to be able to add functions such as application layer processing and functional service to the base model as a functional module with a packet communication device having only a simple

forwarding function of, for example, layer 2 or layer 3 as

a base model, in which when a plurality of functional

services are provided, the packet communication device has

such performance scalability as to be able to easily enhance

5   and upgrade the performance without suspending the service

by adding a functional module in accordance with necessary

performance of the function.

BRIEF DESCRIPTION OF THE DRAWINGS

10   Fig. 1 is a block diagram showing a function block of

a packet communication device according to a first

embodiment of the present invention;

Fig. 2 is a block diagram showing one structure of an

interface module of a packet communication device according

15   to the present invention;

Fig. 3 is a block diagram showing an example in which

a packet is forwarded within a packet communication device

according to the present invention;

Fig. 4 is a block diagram showing another example in

20   which a packet is forwarded within a packet communication

device according to the present invention;

Fig. 5 is a block diagram showing further another

example in which a packet is forwarded within a packet

communication device according to the present invention;

Fig. 6 is a block diagram showing a structural example of a function search table of the packet communication device according to the present invention;

Fig. 7 is a block diagram showing a structural example of a function processor of the packet communication device according to the present invention;

Fig. 8 is a block diagram showing an example in which a packet is forwarded within the packet communication device according to the present invention, and showing an example in which forwarding information is imparted to the packet within the function processor;

Fig. 9 is a block diagram showing a structural example of the packet communication device according to second or third embodiments of the present invention;

Fig. 10 is a block diagram showing a structural example of an ingress forwarding processor of the packet communication device according to the second embodiment of the present invention;

Fig. 11 is a block diagram showing a structural example of an ingress forwarding processor of the packet communication device according to the third embodiment of the present invention;

Fig. 12 is a block diagram showing structure of a conventional packet communication device; and

Fig. 13 is a block diagram showing structure of a conventional packet communication device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

Fig. 1 shows the general structure of a packet communication device according to the first embodiment of the present invention. A plurality of interface elements (IFE) 2-1 to 2-4, and a plurality of function processors (FP) 3A to 3D for performing various functional processing, are connected to the packet communication device. The packet communication device has a switch element (SWE) 1, to which the IFE 2-1 to 2-4 are connected, for switching, and a controller (CTRL) 4. The CTRL4 controls the entire device, and processes the routing protocol. Specifically, using routing protocols such as RIP (Router Information Protocol) and OSPF (Open Shortest Path First), the CTRL4 collects path information from other devices for entry. The plurality of IFE2-1 to IFE2-4 is connected to ports P1 to P4 of the SWE1 respectively. Also, FP3A to FP3D are connected to ports P5 to P8 of the SWE1 respectively.

With reference to Fig. 2, the description will be made of an example of the structure of IFE2. The IFE2 has a network interface 21, a layer 2 processor 22, an ingress

forwarding processor 23, a packet buffer 24, a switch element interface (SWE I/F) 25.

A frame inputted into the device is subjected to physical layer processing in the network interface 21. When it is connected to Ethernet (registered trade-mark), the frame is subjected to MAC (Media Access Control) layer processing. Thereafter, in the layer 2 processor 22, the object output port of the destination MAC address will be identified by using the destination address, the source address, VID (VLAN ID), FDB (Forwarding Database) and the like.

Thereafter, the frame (which is referred to as packet in the layer 3) is inputted into an ingress forwarding processor 23. The ingress forwarding processor 23 is composed of a function search key extractor 232, a function search table 233 and a destination FP header generator 234. From the packet, header information is extracted by the function search key extractor 232. With this header information as a key, the function search table 233 tells whether or not functional processing is necessary, and which functional processing is required.

Next, the functional processing will be described. In the present embodiment, the functional processing means processing of a higher order than the layer 3. As its example, there are security processing such as filtering,

processing of application layer and the like. When filtering processing is performed as, for example, functional processing, the FP3A takes such structure as shown in Fig. 7. In Fig. 7, the FP-A 3A is composed of a filtering processor 32 peculiar to the filtering processing and a filtering table 33 in addition to a header processor 31 which exists in all FP3. From the packet inputted into the FP-A 3A, address information is extracted by the header processor 31 to transmit to the filtering processor 32. With this address information as a key, the filtering table 33 will be searched to acquire information on approval/disapproval of specific address passage. According to the search result, only a packet having an approved forwarding address is outputted from the FP-A 3A, and a packet having a disapproved forwarding address is discarded by the FP-A 3A. By the above-described functional processing in the FP-A 3A, it becomes possible to provide a packet communication device having a security function.

With reference to Fig. 6, the description will be made of structure of the function search table 233 shown in Fig. 2. With an address 2331 (destination address, source address, or a combination of the destination address and source address) within the header information in the incoming packet and the like as a key, a required function 2332 and an output port 2333 for the packet will be searched.

Any entries in this function search table 233 can be added and deleted from the CTRL4 even when the packet communication device is in service.

Using the search result from the function search table 233, a port number (one or plural) of FP3 corresponding to the functional processing to be required and a port number of IFE2 at the output destination are added to the packet at the destination header generator 234 (Fig. 2). Whne the functional processing is not required, only the port number of IFE2 at the output destination is added to the packet. In this case, it is assumed that the port number is a value for identifying a connection port of SWE1 and has been allocated uniquely within the packet communication device in advance.

A packet outputted from an ingress forwarding processor 23 (Fig. 2) is inputted into a packet buffer 24. This packet buffer 24 is used for queuing when, of ports connected to SWE1, output requests from the plurality of IFE2 overlap in a specified port. In order to reduce waiting time for output due to the queuing, the packet buffer 24 may be constructed such that they are divided into a plurality of output queues corresponding to output destinations of packets (generally referred to as VOQ (Virtual Output Queue).

The packet outputted from the packet buffer 24 is outputted to SWE1 shown in Fig. 1 through the switch element interface (SWE I/F) 25.

Next, the description will be made of how the packet 5 will be forwarded in the packet communication device.

Packet Forwarding Requiring No Function

With reference to Fig. 3, the description will be made of an example in which a packet requiring no functional 10 processing is forwarded. When the packet is inputted into IFE2 (2-1 in this example), search processing is performed in the function search table 233 (Fig. 2) on the basis of address information in the header imparted to the packet. In this example, as the search result, only output port 15 number P4 is obtained (which corresponds to a case of address a on the function search table shown in Fig. 6). The packet will be forwarded to IFE2-4 at the destination through SWE1 on the basis of information of the port number P4 imparted at a destination header generator 234.

20 In the above-described example, only forwarding processing of a packet is performed. When no functional processing is required for the packet communication device, FP-A to FP-D 3A to 3D will not be needed. In this case, it can be made into a packet communication device having simple 25 structure at low cost.

When it becomes necessary to add functional processing in addition in the future, it is possible to add a desired functional processor without suspending an operation of the packet communication device.

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Packet Forwarding Requiring One Functional Processing

Fig. 4 shows an example in which a packet requiring one functional processing is forwarded.. When the packet is inputted into IFE2 (2-1 in this example), search processing

10 is performed at the function search table 233 (Fig. 2). Even in this example, the search processing is performed on the basis of address information in the header information imparted to the packet. As the search result, a function of FP-A 3A and a port number P3 of IFE2 are obtained (which

15 corresponds to a case of address b on the function search table shown in Fig. 6). To the packet, a port number P5 corresponding to FP-A 3A and port address information corresponding to a port number P3 of egress IFE2 are stacked and imparted at the destination header generator 234 (Fig.

20 2). In this case, as regards port numbers corresponding to respective FP3A to 3D, it may be possible to arrange the structure such that port numbers corresponding to each functional processing are retained on the function search table 233, or such that the destination header generator 234

is provided with a list of correspondence between functional processing required and port numbers.

First a packet with stacked port numbers (forwarding information) will reach FP-A 3A through SWE1 in accordance with forwarding information corresponding to a port number P5, and be subjected to desired functional processing.

Next, forwarding information (in the case of this example, forwarding information corresponding to the port number P5) imparted at the head is deleted from the packet subjected to the functional processing at a header processor 31. This packet is switched in accordance with forwarding information (in the case of this example, forwarding information corresponding to the port number P3) which will appear at the head next time, and is forwarded to an egress IFE2-3.

Packet Forwarding Requiring Plural Functional Processing

Fig. 5 shows an example of forwarding of a packet when plural functional processing is required. When the packet is inputted into IFE2 (IFE-1 2-1 in this example), search processing is performed at the function search table 233 (Fig. 2) on the basis of address information in the header information of the packet. As the search result, a function at FP-A 3A, a function at FP-B 3B and port information P4 of an egress IFE2 (IFE-4 2-4 in the example of Fig. 5) are

obtained (which correspond to a case of address c on the function search table shown in Fig. 6).

Forwarding information concerning a port number P5 of a port, to which FP-A 3A is connected, a port number P6 of
5   a port, to which FP-B 3B is connected, and a port number P4 of a port, to which an egress IFE2 is connected, is stacked to the packet header in order at the destination header generator 23. In this case, concerning port numbers of ports to which respective FP-A to FP-D 3A to 3D are connected
10   respectively, it may be possible to arrange the structure such that port numbers corresponding to each functional processing are retained on the function search table 233, or such that the destination header generator 234 is provided with a list of correspondence between functional
15   processing and port information.

In Fig. 5, a packet with stacked forwarding information reaches FP-A 3A through SWE1 first in accordance with forwarding information of a port number P5 and is subjected to desired functional processing. After the
20   functional processing, forwarding information (in the case of this example, information corresponding to the port number P5) imparted at the head of the packet is deleted at a header processor 31 (Fig. 7). Next, the packet reaches FP-B 3B in accordance with forwarding information (in the
25   case of this example, information corresponding to the port

number P6) which will appear at the head next time, and is subjected to the desired functional processing. After subjected to the functional processing, similarly as above, forwarding information (in the case of this example,

5   information corresponding to the port number P6) imparted at the head of the packet is deleted at the header processor 31 (Fig. 7). Thus, in accordance with forwarding information (in the case of this example, information corresponding to the port number P4) which will appear at

10   the head next time, the packet will be switched so that it is forwarded to the egress IFE2-4.

   In this example, a case where the packet is subjected to two types of functional processing is shown, but when subjected to n types of functional processing, information

15   corresponding to n-pieces of port numbers which correspond to respective FP can be stacked as forwarding information in advance. Also, when the packet has priority in plural functional processing, a port number of FP corresponding to functional processing with higher priority is stacked at the

20   head of the forwarding information. Thereby, it becomes possible for each packet to be subjected to functional processings considering priorities of them. For example, only a packet which has passed through the filtering processing is subjected to the next functional processing.

Therefore, it becomes possible to perform processing with efficiency.

In the examples described above, the function search table 233 (Fig. 2) determines functions of FP-A to FP-D 3A
5   to 3D and port numbers of egress IFE-1 to IFE-4 2-1, but it is also possible to arrange the structure such that a port number of egress IFE2 can be determined by any of FP-A to FP-D 3A to 3D as shown in Fig. 8.

Fig. 8 shows a flow of processing when search
10   processing of the port number of egress IFE2 is performed by FP-B 3B. For example, an example of application in which when the base system is for IPV4, FP-B 3B is made into an IPV6 processing module, or an example of application in which when the base system is for the layer 2 switch, FP-B
15   3B is made into the layer 3 processing module. By adopting such structure, it is also possible to perform processing responsive to a different protocol or a different layer.

In Fig. 8, when a packet is inputted into IFE2 (IFE-1 2-1 in this example), search processing is performed by the
20   function search table 233 (Fig. 2) on the basis of address information in the header information of the packet. As the search result, the function of FP-A 3A and the function of FP-B 3B are obtained. Information concerning a port number P5 of a port, to which FP-A 3A is connected, and a port number
25   P6 of a port, to which FP-B 3B is connected, is stacked to

the packet in order at the destination header generator 234 as forwarding information.

In this case, regarding the port number corresponding to each of the respective FP-A to FP-D 3A to 3D, it may be possible to arrange the structure such that port numbers corresponding to each functional processing are retained on the function search table 233, or such that the destination header generator 234 is provided with a list of correspondence between functional processing and port information.

The packet to which forwarding information stacked has been imparted reaches FP-A 3A through SWE1 first in accordance with forwarding information corresponding to the port number P5 and be subjected to desired functional processing. After subjected to the functional processing at FP-A 3A, forwarding information (in the case of this example, information corresponding to the port information P5) imparted at the head of the packet is deleted at the header processor 31 (Fig. 7). The packet is forwarded FP-B 3B in accordance with forwarding information (in the case of this example, information corresponding to the port number P6) which will appear at the head next time.

In FP-B 3B, as the result of search processing based on address information in the header information, the packet obtains port information (in the case of this example,

corresponds to the port number P4 of a port to which IFE-4 2-4 is connected) of egress IFE2. After the forwarding information (in the case of this example, information corresponding to the port number P6) imparted at the head

5 of the packet is deleted at the header processor 31 (Fig. 7), new forwarding information corresponding to the port number P4 of the port, to which the egress IFE2 is connected is attached to the packet header, and thereafter, the packet will be switched so that it is forwarded to an egress IFE-4

10 2-4 in accordance with this forwarding information.

Second Embodiment

In the first embodiment, the description has been made of a case where each of FP-A to FP-D 3A to 3D has a functional processing function different from one another. In a packet

15 communication device according to the second embodiment, in a case where the device is insufficient in processing capacity when an attempt is made to execute a predetermined function with one FP3, the processing will be performed by additionally installing a plurality of FP3, each having the

20 same function. In other words, a plurality of FP3 having the same function will be installed to perform load balancing among the plurality of FP3.

Fig. 9 shows when three FP (FP-A1 to FP-A3 3A1 to 3A3) of the same type are installed with the objective of

25 increasing the processing capacity of the FP-A 3A as an

example. Each of the FP-A1 to FP-A3 3A1 to 3A3 is connected

to a port P5 to a port P7 of SWE1 respectively. In this case,

FP-B 3B for performing functional processing of a different

type is connected to a port P8 of SWE1.

5   Since the structure of each of IFE-1 to IFE-4 2-1 to

2-4 is the same as the structure shown in Fig. 2, only the

difference will be described below. It is different from

the packet communication device according to the first

embodiment in structure of the ingress forwarding processor

10   23. With reference to Fig. 10, the description will be made

of the structure of this ingress forwarding processor 23.

The ingress forwarding processor 23 for performing

load balancing of functional processing is composed of: a

function search key extractor 232; a function search table

15   233; a destination header generator 234; a function item

table 238; a port table 239; and a HASH function block 237.

When a packet is inputted into the ingress forwarding

processor 23, the function search key extractor 232 reads

out address information from a header imparted to the packet

20   to transmit this information to the function search table

233 and the HASH function block 237. The packet itself is

transmitted to the destination header generator 234. In the

function search table 233, it will be searched with the

address information as a key to find which function the

packet to be inputted requests, and which is a port number, to which IFE2 at the output destination is connected.

One or plural function IDs (which represent function items the inputted packet requires) to be outputted from the
5   function search table 233 will be transmitted to the function item table 238 and the port table 239. Also, the port number of IFE2 at the output destination will be transmitted to the destination header generator 234.

The function item table 238 controls a function item
10   2381 and an installation count 2382 of FP which corresponds to the function item, and outputs an installation count 2382 of FP corresponding to the requested function inputted to the HASH function block 237.

The HASH function block 237 calculates an integer
15   value which is uniquely determined in accordance with the address from the address of the packet and FP installation count 2382 of a function which the packet requests. For example, when the FP installation count 2382 corresponding to a function item 2381 is N (where it is assumed that $1 <$
20   N), in the HASH function block 237, a value of n (where $1 \leq n \leq N$) which is determined fixedly for the address will be calculated by a HASH operation.

As one example of a method of constituting the HASH function block 237, it can be constituted as described
25   below. That is, the HASH function block 237 is preferably

composed of (M-1) types of HASH functions corresponding to
each of a variance number 2 to M (where M is a maximum load
balancing number which is assumed as a system in advance)
so that this can meet various FP installation count 2382.

5   Thus, the HAS function is switched correspondingly to the
FP installation count 2382 to be inputted into the HASH
function block 237. The HASH function is constituted as
described above, whereby it becomes unnecessary to
recombine the HASH functions every time FP 3 is increased

10   and decreased.

The result of HASH operation is transmitted to the
port table 239. The port table 239 is composed of: port
numbers (2391) and function items (2392) of ports, to which
FP-A1 to FP-A3, FP-B 3A1 to 3A3 and 3B are connected

15   respectively, and a VALID flag (2393) indicating whether or
not each of FP 3A1 to 3A3 and 3B is valid, that is, whether
it is ready to use or not.

First, a valid port number 2391 which has been entered
in a n-th place is searched out of port numbers 2391 of FP3

20   which have been entered on the port table 239 and have the
functions concerned, on the basis of an integer value n to
be outputted from the HASH function block 237. Next, the
selected port number is transmitted to the destination
header generator 234. In this case, the valid port number

25   is a port number at which the VALID flag 2393 has been set

validly. For example, in Fig. 10, when function item = A and integer value = 1 are designated on the port table 239, a port #2 will be transmitted to the destination header generator 234, and when function item = A and integer value

5 = 2 are designated, a port #3 will be transmitted to the destination header generator 234.

The destination header generator 234 stacks forwarding information corresponding to an egress IFE port number received from the function search table 233 and all

10 port numbers received from the port table 239 to impart to the packet.

As described above, a packet communication device according to the second embodiment performs load balancing among a plurality of FPs having the same function on the

15 basis of the address of the packet, whereby it is possible to provide functional processing capability as needed.

Also, since packets having the same address can be subjected to the processing always by means of the function of the HASH function block 237 at the same FP3, when being

20 subjected to functional processing, it is possible to keep integrity of the sequence of flow of the packet, and therefore, it becomes also possible to assemble the packet and be subjected to processing at the application layer.

In order to increase the processing capability of a

25 specific function, the FP3 concerned will be added and

installed on an empty port of SWE1. At this time, a processor
installation count of the function concerned of the function
item table 238 is updated, a function item of FP3 newly added
and a port number is added to the port table 239. In this
5   case, it is not necessary to change a function search table
233 having an enormous amount of entries of address, but
since the processing is completed only by updating the
function item table 238 and the port table 239, it becomes
possible to extend or delete functions without suspending
10   the service.

Renewal of information of the function item table 238
and the port table 239 associated with changes (extension,
deletion, the above-described changes in setting of
validity and invalidity, and the like) of functions is
15   performed by a management console 5 to be connected to CTRL4
(Fig. 9) through CTRL4.

Third Embodiment

The description will be made of an example in which
20   IFE2 for constituting a packet communication device for
performing load balancing of functional processing among a
plurality of FP3 has different structure from a packet
communication device according to the second embodiment.

Since a packet communication device according to the
25   third embodiment is similar to the packet communication

device according to the second embodiment shown in Fig. 9
in general structure, the description will be made with a
particular emphasis on differences with the packet
communication device according to the second embodiment

5   with reference to Fig. 9 appropriately.

Since the internal structure of each of IFE-1 to IFE-4
2-1 to 2-4 of the packet communication device according to
the third embodiment is also the same as the structure shown
in Fig. 2 except a portion to be described below as in the

10 case of the packet communication device according to the
second embodiment, the description thereof will be omitted.
It is different from the packet communication devices
according to the first and second embodiments in structure
of the ingress forwarding processor 23. With reference to

15 Fig. 11, the description will be made of the structure of
this ingress forwarding processor 23. In this respect, in
the following, component elements identical to those shown
in Fig. 10 are designated by the identical reference
numerals, and description thereof will be omitted.

20 The ingress forwarding processor 23 corresponding to
load balancing of functional processing is composed of: a
function search key extractor 232; a function search table
233; a destination header generator 234; a function decoder
235; a function register 236; and a HASH function block 237.

The function register 236 is composed of a function register A 236A, a function register B 236B, a function register C 236C, ... which are to be disposed in accordance with the type of function.

5   When a packet is inputted into the ingress forwarding processor 23, the function search key extractor 232 reads out address information from a header imparted to the packet to transmit this information to the function search table 233 and the HASH function block 237. The packet itself is
10   transmitted to the destination header generator 234.

In the function search table 233, it will be searched with the address information as a key to find a function the packet requests, and a port number, to which IFE2 at the output destination is connected. One or plural functions
15   ID (information concerning function item) to be outputted from the function search table 233 will be transmitted to the function decoder 235. Information concerning the port number of IFE2 at the output destination also will be transmitted to the destination header generator 234. The
20   function decoder 235 decodes function ID to be inputted to select any of a plurality of function registers 236 (236A to 236C).

The respective function registers 236A, 236B,... are composed of: an installation count 2361 of usable FP3
25   corresponding to the function; a port number 2362 indicating

to which port of SWE1 (Fig. 8) FP3 is connected; and a VALID flag 2363 indicating whether or not FP3 which is installed on the port is usable.

The HASH function block 237 receives FP installation counts 2361 from the respective function registers, and calculates an integer value which is uniquely determined on the basis of the address inputted from the function search key extractor 232 and the FP installation counts 2361 to return the result to the function register 236.

For example, when the FP installation count 2361 corresponding to a certain function is n (where it is assumed that 1 < n), the HASH function block calculates any of values from 1 to n which is determined fixedly to the address in the header information to be imparted to the packet by a HASH function to return to the function register 236. The respective function registers 236 transmit, to the destination header generator 234, a valid port number which has been stored at an address position corresponding to an integer value obtained from the HASH function block 237. In this case, the valid port number is a port number at which the VALID flag (2361) has been set "validly".

For example, in Fig. 11, when integer value = 1 is returned to a function register 236A corresponding to the function A, a port number corresponding to port a will be transmitted to the destination header generator 234, and

when integer value =2 is returned, a port number
corresponding to port b will be transmitted to the
destination header generator 234. The destination header
generator 234 stacks forwarding information corresponding
to a port number, to which an egress IEF is connected,
received from the function search table 233 and all port
numbers received from the function register 236 to impart
to the packet.

As described above, the load balancing is performed
among a plurality of FPs having the same function on the
basis of the address of the packet, whereby it is possible
to provide functional processing capability as needed.

Also, since packets having the same address can be
forwarded to the same FP3 for processing, when being
subjected to functional processing, it is possible to
prevent the order of flow of the packet from being reversed,
and therefore, it becomes also possible to assemble the
packet and be subjected to processing at the application
layer.

When increasing the processing capability of a
specific function, if the FP3 concerned is added and
installed on an empty port of SWE1, a new port number 2362
is added to the function register 236 concerned, and the
installation count 2361 and the VALID flag 2363 are updated,
it will be possible to easily add the load balancing number

from n-parallel to n + 1 parallel, n + 2 parallel, ... In this case, it is not necessary to change the function search table 233 having an enormous amount of entries of address, but since the processing is completed only by changing the

5   function register 236, it becomes possible to extend or delete functions without suspending the service.

The processing procedure of expansion/removal becomes simpler in the sense that in the packet communication device according to the second embodiment

10   shown in Fig. 10, it is necessary to change the function item table 238 and the port table 239, whereas in the packet communication device according to the third embodiment, a change only in the function register 236 will suffice. The function register 236 is normally changed by a management

15   console 5 (Fig. 9) to be connected to CTRL4.

In this respect, the structure of the HASH function block 237 in the packet communication device according to the third embodiment is capable of easily coping with an increase and decrease of the FP3 because it has the similar

20   structure to one described in the second embodiment.

As described above, according to the packet communication devices of the first to third embodiments, addition and removal of a function can be easily performed. Specifically, it is possible to provide such a packet

25   communication device that a packet communication device

based on the provision of only a simple forwarding function of the layer 2 or the layer 3 is made into a base model and when a functional service such as application layer processing or security is required, these can be added to

5   the base model as a functional packet processing module or a functional switch module as needed.

Further, correspondence relationship between a flow of packet and the function concerned, and relationship between various functions, their installation counts and

10   physical installation positions are separated and controlled, whereby it is possible to provide a packet communication device capable of easily adding and removing a functional packet processing module without suspending the service.

15   In the first to third embodiments described above, the description has been made of an example in which a packet is forwarded on the basis of forwarding information and a port number which has become unnecessary after termination of the processing is deleted successively from the

20   forwarding information. In contrast to this, while the packet is being forwarded within the packet communication device, it may be possible to continue to retain all the forwarding information in a stacked state and to determine the next forwarding destination according to pointer

25   information indicating where the next forwarding

destination is. In this case, the forwarding information and the pointer information can be erased at a point of time whereat all the processing has been completed. For example, at a step before the packet is transmitted to the outside

5   of the device after it is forwarded to the egress IFE2, the above-described forwarding information and pointer information can be erased.

Also, in the foregoing, the description has been made of an example in which the forwarding information is handled

10   as so-called header information in which the forwarding information is added to the head of the packet, but the present invention is not limited thereto.

In addition, it goes without saying that a number of ports to be provided on the packet communication device and

15   a number of FP3 and IFE4 can be increased and decreased as needed.

In the above-described embodiments, "packets having the same address" may be packets having the same source address, or may be packets having the same destination

20   address. Or, it may be packets having the same source destination address. Further, it may be packets to be outputted to the same line interface.

The present invention includes the following example as an embodiment.

25   [1] A packet communication device, comprising:

a plurality of line interfaces capable of, of reception and transmission of a packet, at least either;

a plurality of functional processors for performing functional processing of incoming packets received by the plurality of line interfaces;

a plurality of ports to which the plurality of line interfaces and the plurality of functional processors are connected;

a function entry unit in which correspondingly to packet address information imparted to the incoming packet, a function item of functional processing which the incoming packet requires, and an output port address of a port to which the line interface for transmitting the incoming packet after processing to the outside is connected are to be registered;

a connection number entry unit in which a connection number for each function item is registered correspondingly to function items of the plurality of functional processors;

a port entry unit in which function items of the functional processors to be connected are entered correspondingly to respective port addresses of the plurality of ports;

a function processor for deriving data which uniquely corresponds to a combination of the connection number to be obtained from the connection number entry unit and the

packet address information correspondingly to function

types to be obtained from the function entry unit on the

basis of the packet address information; and

a forwarding information generator which reads out

5 function items corresponding to the packet address

information from the function entry unit, reads out port

addresses corresponding to a combination of the function

items and the data to be derived at the function processor

from the port entry unit; reads out output port addresses

10 corresponding to a combination of the port address and the

packet address information from the function entry unit,

generates forwarding information within the device on the

basis of the port address and the output port address to

impart to the incoming packet.

15 [2] A packet communication device, comprising:

The packet communication device according to [1] or [2],

wherein a plurality of functional processors to be used for

performing functional processing of incoming packets

received by any of the plurality of line interfaces;

20 a plurality of ports, to which the plurality of line

interfaces and the plurality of functional processors are

connected;

a function entry unit in which correspondingly to

packet address information imparted to the incoming packet,

25 a function item of functional processing which the incoming

packet requires, and an output port address of a port to which a line interface for transmitting the incoming packet after the processing to the outside is connected are to be entered;

5   a connection information entry unit in which a number of connections of the plurality of functional processors and port address to be connected are classified for each function item described above for registration;

a function processor for deriving data which uniquely 10 corresponds to a combination of the connection number to be obtained from the connection information entry unit and the packet address information correspondingly to function types to be obtained from the function entry unit on the basis of the packet address information; and

15   a forwarding information generator which reads out function items corresponding to the packet address information from the function entry unit, reads out port addresses corresponding to a combination of the function items and the data to be derived at the function processor 20 from the connection information entry unit; reads out output port addresses corresponding to a combination of the port address and the packet address information from the function entry unit, and generates forwarding information within the device on the basis of the port address and the output port 25 address to impart to the incoming packet.

[3] The packet communication device according to [1] or [2],
wherein when of the plurality of functional processors, a
connection number of the same function, which is a
connection number of functional processors having the same
function, is changed, the function processor derives data
that uniquely corresponds to a combination of the connection
number after the change to be obtained from the connection
information entry unit and the packet address information
correspondingly to function type to be obtained on the basis
of the packet address information from the function entry
unit.

[4] The packet communication device according to [3],
wherein the function processor has a plurality of HASH
function arithmetic units, and when the connection number
of the same function is changed, of the plurality of HASH
functions, there is selected a HASH function corresponding
to the connection number of the same function after the
change.

[5] A communication method to be applied to a packet
communication device having:

    a plurality of line interfaces capable of, of
reception and transmission of a packet, at least either;
and

    a plurality of ports to which the plurality of line
interfaces are connected, and to which at least one

functional processor to be used in order to perform

functional processing of an incoming packet received by any

of the plurality of line interfaces can be installed as

needed, comprising the steps of:

5   judging function item to be requested by the incoming

packet;

          determining a forwarding port of the incoming packet

in response to the function item judged, and imparting, to

the incoming packet, forwarding information that is

10   information for designating the forwarding port; and

          switching the forwarding path when forwarding among

the plurality of ports on the basis of the forwarding

information.

[6]   A communication method to be applied to a packet

15   communication device having:

          a plurality of line interfaces capable of, of

reception and transmission of a packet, at least either;

          one or a plurality of functional processors to be used

in order to perform functional processing of an incoming

20 · packet received by any of the plurality of line interfaces;

and

          a plurality of ports to which the plurality of line

interfaces and one or a plurality of functional processors

described above are connected, comprising the steps of:

judging function item to be requested by the incoming

packet;

determining a forwarding port of the incoming packet

in response to the function item judged, and imparting, to

5   the incoming packet, forwarding information that is

information for designating the forwarding port; and

performing functional processing on the incoming

packet, determining, as a forwarding port, a port to which

a line interface for transmitting the incoming packet to the

10   outside, of the plurality of line interfaces, on the basis

of the result of the functional processing, is connected,

and imparting, to the incoming packet, forwarding

information corresponding to the forwarding port.

[7]   A communication method to be applied to a packet

15   communication device having:

a plurality of line interfaces capable of at least

either of reception and transmission of a packet,;

a plurality of functional processors capable of

performing the same functional processing on an incoming

20   packet received by any of the plurality of line interfaces;

and

a plurality of ports to which the plurality of line

interfaces and the plurality of functional processors are

connected, comprising the steps of:

judging function item to be requested by the incoming packet;

determining a forwarding port of the incoming packet in response to the function item judged, and if when

5 imparting, to the incoming packet, forwarding information that is information for designating the forwarding port, the same address information is imparted to the incoming packet to be received successively by any of the plurality of line interfaces, fixedly designating a port to which the same

10 functional processor is connected, of the plurality of functional processors, as the forwarding port; and

switching the forwarding path on the basis of the forwarding information when forwarding the incoming packet among the plurality of ports.

15 [8] A communication method to be applied to a packet communication device having:

a plurality of line interfaces capable of, of reception and transmission of a packet, at least either;

a plurality of functional processors for performing

20 functional processing on an incoming packet received by any of the plurality of line interfaces; and

a plurality of ports to which the plurality of line interfaces and the plurality of functional processors are connected, comprising the steps of:

entering a function item of the functional processing which the incoming packet requires and an output port address of a port to which a line interface for transmitting the incoming packet after the processing to the outside is

5   connected in a function entry table correspondingly to packet address information imparted to the incoming packet;

entering a connection number for each function item in a connection number entry table correspondingly to function items of the plurality of functional processors;

10   entering function items of a functional processor to be connected in a port entry table correspondingly to respective port addresses of the plurality of ports;

searching the function items from the function entry table on the basis of the packet address information, and

15   searching a connection number corresponding to the function item from the connection number entry table;

performing the function processing for deriving data that uniquely corresponds to a combination of the connection number to be obtained in the search step and the packet

20   address information; and

generating forwarding information within the device from a port address which is obtained by searching the port entry table on the basis of the function item to be obtained by searching the function entry table on the basis of the

25   packet address information and the data to be derived by the

function processing step, and an output port address which
is obtained by searching the function entry table on the
basis of the packet address information, and imparting
forwarding information to the incoming packet.

5 [9] A communication method to be applied to a packet
communication device having:

a plurality of line interfaces capable of, of
reception and transmission of a packet, at least either;

a plurality of functional processors to be used in
10 order to perform functional processing on an incoming packet
received by the plurality of line interfaces; and

a plurality of ports to which the plurality of line
interfaces and the plurality of functional processors are
connected, comprising the steps of:

15 entering, correspondingly to the packet address
information imparted to the incoming packet, function items
of functional processing which the incoming packet
requires, and output port address of a port, to which a line
interface for transmitting the incoming packet after the
20 processing to the outside is connected, in a function entry
table;

classifying a connection number of the plurality of
functional processors and a port address to be connected
every the function item to enter in a connection information
25 entry table;

searching the function entry table on the basis of the packet address information, searching the connection information entry table on the basis of function item to be obtained, and performing function processing for deriving

5   data that uniquely corresponds to a combination of the connection number to be obtained and the packet address information; and

generating forwarding information within the device from the port address which is obtained by searching the

10   connection information entry table on the basis of the function item to be obtained by searching the function entry table on the basis of the packet address information and the data to be derived from the function processing step, and an output port address which is obtained by searching the

15   function entry table on the basis of the packet address information, and imparting to the incoming packet.